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Short duration of music modify the heart rate variability

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Abstract: *Background:* There are contradictory findings regarding the effect of music on heart rate variability. Reports mention that the music increases the parasympathetic markers of heart rate variability. While some report no change in it. *Method:* We set out to study the acute effect of music on heart rate variability in 15 healthy male medical students of age 20-36 years. Their resting heart rate variability in eyes closed state for five minutes was recorded thrice: once without listening music, secondly during listening instrumental music for five minutes and thirdly after listening it. Their subjective feeling regarding music and its influence on the brain were documented. Data was compared using the Friedman test followed by Wilcoxon-signed rank test, considering P significant at ≤ 0.05. *Results:* The mean respiratory rate was significantly higher during music as compared to before listening it. There was a significantly higher HF power after listening to music than during listening it [703.5 (247.25-1195) > 529 (213-699), p=0.026]. As well as, the total power of heart rate variability was significantly higher after music listening as compared to before listening it [2472.5 (1351-4178.75) > 2147.5 (1072.5-3208.25), p=0.035]. All participants felt that they were relaxed during and after the short music session. *Conclusions:* The instrumental-soft relaxing music for short duration (five minutes) can increase the parasympathetic activity of the heart. The effect of music on vagus supply to the heart remains in higher level even after over of music. It makes people feel relaxed and helps to minimize their stress instantly in their working place.

Keywords: Heart Rate variability, Instrumental Music, Students, Stress

Abbreviations: HRV-Heart Rate Variability, HF- High Frequency Power, LF: Low frequency power, n.u: normalized unit, BMI-Body Mass Index, SBP: Systolic Blood Pressure, DBP- Diastolic Blood Pressure, PR-Pulse Rate, RR-Respiratory Rate

Introduction

Music is considered to be one of the pain relieving factors during emotional stress. When persons are in the stressed condition music is believed to increase the relaxation of brain neurons and stimulate the brain reward center [1]. Music making (i.e. learning to sing or to play a musical instrument) is also considered one of the tools for promoting brain plasticity [2]. Listening to music (classical) improves the cardiovascular recovery from the stress [3]. According to a study four weeks of music therapy enhances sports performance by decreasing the pre-competition stress, as concluded by assessing the heart rate variability; HRV in elite shooters [4]. The HRV is one of the best tools to quantify the autonomic drive to the heart than the other reflex tests. It is widely used indirect non-invasive measure of cardiac vagal nerve function [5]. There are studies which show that music changes the HRV in different ways in men and women. In women, the relaxant baroque and excitatory heavy metal music slightly decreases the global HRV [6]. Whereas, in men, the excitatory heavy metal music acutely decreases the global HRV, while no change is observed during the relaxing classical baroque music [7].

However, classical and Nasyid music in particular is considered to enhance more relaxing situation as compared to the Rock music [8]. On electroencephalogram, brain alpha activity (i.e. relaxed state of the brain) is highly increased while listening to the classical music as compared to the rock music. A report also mentions that relaxing music can increase the activity of the parasympathetic nervous system [9]. Hence, literature showed contradictory findings regarding the effect of music (classical or rock

music) on HRV. This led us with the aim to study the acute effect of short duration music (instrumental) on HRV in adult males. Hence, the objective of the study is to compare the acute effect of music on HRV in eyes closed state at three different time points (viz: before listening music, during listening and after listening) in adult males.

Material and Methods

This study was conducted in 15 healthy male volunteers, age 20-36 years. Subject population was medical students. To avoid diurnal variation recording was done after their classes were over, in the evening.

A. *Selection of Music:* Music is a matter of personal choice. A music which can be pleasant to one individual might not be perceived the similarly by the other individual. Therefore, before selecting music for the study, we analysed many soothing types of music (instrumental pieces). Later, five instrumental pieces were selected. Among these five, one was randomly selected (lottery method) for the study. The included music was from the album 2005 erotic dreams with a track list of respect (all my relations).

B. *Subject preparation and recording of anthropometric and cardiorespiratory variables:* At first the informed consent was taken from the volunteers. After that they were briefed about the procedure and the study plan. We explained them the procedure for recording the HRV too. They were explained that their resting HRV will be recorded thrice: once before listening music, secondly during listening to it and thirdly after listening to music; each session consisting of five minute period. (After explaining about the procedure) Their age, height, weight, and BMI were recorded and calculated respectively. In addition, they were asked to rest for 15 minutes in a semi-reclined posture, and their cardio-respiratory (pulse rate, systolic and diastolic blood pressure and respiratory rate) parameters were recorded prior to the HRV recording. The cardio-respiratory parameters were again recorded after over of the music session.

C. *Standard Short-term Heart Rate Variability Assessment:*

i. *Data Acquisition:* The Polar S810i and Polar Precision Performance SW (version-4.01.029) software was used for recording and analyzing the R-R intervals in all the volunteers. In an eye closed alert state the resting R-R intervals were recorded for five minute in a semi-inclined posture in a comfortable chair. After baseline recording, music was played on the headphone placed in the subjects ears and simultaneously HRV was recorded for five minutes when the music was on play. Immediately, after the music session, HRV was recorded for another five minutes. Finally, at the end of the session their cardiovascular parameters were again recorded. Hence, three point data (viz: HRV before music, HRV during music and HRV after music) were recorded and subjected to analysis.

ii. *Data Transmission and Analysis:* The recorded data were transmitted to the computer by using Polar Precision Performance SW software via infrared connection. Ectopic beats were discarded and missing data were replaced by averaging nearest two RR intervals. Corrected data were subjected to fast Fourier transformation by using Kubios HRV (version 2.0) software, Kuopio University, Finland, for the power spectral analysis. The beat-to-beat raw data for determination of HRV were processed according to the Task Force Guidelines, 1996 [10].

iii. *HRV Analysis and Parameters Recorded:* The obtained data were analyzed by three methods, time domain, frequency domain and non-linear method for parameters of HRV using Kubios HRV (version 2.0) software, Kuopio University, Finland. Measures recorded and analysed were as follows:

Time Domain Measures: The major time domain parameters computed were SDNN (standard deviation of the NN intervals),

RMSSD (square Root of the Mean Square of Successive differences between adjacent NN intervals), NN50 (number of pairs of successive NN intervals greater than50 ms), pNN50 (proportion derived by dividing NN50 by the total number of NN intervals)

Frequency Domain Measures: The frequency domain parameters were analyzed by fast Fourier transformation using Kubios HRV (version 2.0) software, Kuopio University, Finland. The major frequency domain parameters computed were low frequency (LF) power, high frequency (HF) power, total power, LF/HF ratio, LF normalized unit (n.u.), HF normalized unit (n.u.)

Non- Linear measures: The nonlinear analysis was performed using Poincare plot. The nonlinear parameters computed were SD1 (vagal activity), SD2 (sympathetic influence), SD1/SD2 (Sympatho-vagal balance).

D. *Subjective feeling:* A self designed questionnaire was used to know the feeling of the subject after listening to the music.

E. *Statistical analysis:* We compared three point data by using the Friedman test followed by Wilcoxon-signed rank test. P value was considered significant at ≤ 0.05.

F. *Ethical Clearance:* Gandaki medical college institutional ethical clearance was obtained prior to the study as per the guidelines of the Nepal health research council (NHRC).

Results

The mean age and body mass index of the volunteers were 25.93±3.45 years and 23.23±2.20, respectively. The cardiovascular parameters of the volunteers at rest are displayed in median and quartiles, Table 1. There was no significant difference on comparing cardiovascular variables between before and after the music session.

Table-1: The cardiovascular parameters of the volunteers at resting state, n-15

Variables	Median (quartile1-quartile3)
Systolic blood pressure (SBP)	115 (110.50-119.5) mm Hg
Diastolic blood pressure (DBP)	75 (70-80) mm Hg
Pulse rate (PR)	69 (57.25-73.75)/ minute
Respiratory Rate (RR)	16.5 (14.75-18.25)/minute

Table-2: Time domain measures of HRV at three time points (before, during and after listening music), n-15

Time Domain Measures	Median (quartile1-quartile3)			B vs. D (p1)	D vs. A (p2)	B vs. A (p3)
	Before Music (B)	During Music (D)	After Music (A)			
Mean RR	872.1 (809.15-1004.53)	884.15 (840.10-1006.3)	869.35 (822.48-991.3)	0.03*	0.14	0.73
SDNN	50.8 (40.98-62.05)	51.6 (35.98-68.08)	52.35 (37.25-63.53)	0.61	0.19	0.82
STD HR	3.62 (3.19-4.68)	3.54 (3.27-4.61)	3.72 (3.31-5.07)	0.9	0.08	0.73
RMSSD	43 (35.53-57.28)	40.05 (34.33-53.1)	43.7 (34.45-59.63)	0.87	0.75	0.95
NN50	81.5 (43.75-116.75)	74 (36.25-120)	92 (49.25-120)	0.9	0.38	0.67
PNN50	23.05 (12.63-39.68)	21.9 (11.30-39.25)	26.6 (13.55-39.2)	0.97	0.52	0.49

Note: * denotes significant differences, p1: p value on comparing before music versus during music; p2: p value on comparing during music versus after music; p3: p value on comparing before music versus after music.

I. *Subjective Feeling:* All subjects reported that they felt relaxed after listening to the music. Further, they mentioned that the music was soothing and their brain was relaxed during listening to the music.

II. *Comparison of HRV measures among three points data:* On comparing three point data (before music vs. during music vs. after music), we found that mean RR was significantly higher during music as compared to before music Table 2. In addition, there was a significantly higher HF power after listening to music as compared to during listening music, Table 3. As well as, the total power was significantly higher after music listening as compared to before listening it. However, on all data points there were no significant differences in non-linear measures of HRV, Table 3.

Table-3: Frequency and non-linear measures of HRV at three time points (before, during and after listening music), n-15

Variables		Median (quartile1-quartile3)			B vs. D (p1)	D vs. A (p2)	B vs. A (p3)
		Before music (B)	During music (D)	After music (A)			
Frequency domain	LF power	613.5 (382.25-850.75)	598 (352.75-960.25)	539.5 (426.75-1429.5)	0.82	0.084	0.221
	LF nu	54.95 (39.25-66.55)	53.45 (41.03-67.28)	54.65 (36.65-68.30)	0.85	0.87	0.85
	HF power	759.5 (187.75-1093)	529 (213-699)	703.5 (247.25-1195)	0.51	0.026*	0.07
	HF nu	45.05 (34.20-60.75)	46.55 (32.73-58.98)	45.35 (31.7-63.35)	0.73	0.87	0.8
	Total power	2147.5 (1072.5-3208.25)	2305.5 (989-4250)	2472.5 (1351-4178.75)	0.06	0.363	0.035*
	LF/HF	1.26 (0.65-1.92)	1.16 (0.70-2.06)	1.21 (0.58-2.15)	0.87	0.92	0.59
Non-linear measures	SD1	30.45 (25.13-40.55)	28.35 (24.28-37.60)	30.95 (24.43-42.23)	0.87	0.82	0.92
	SD2	65.8 (50.93-74.93)	66.7 (46.98-81.95)	65.7 (46.50-77.85)	0.45	0.51	0.86
	SD1/SD2	0.52 (0.47-0.58)	0.49 (0.39-0.57)	0.53 (0.47-0.58)	0.36	0.3	0.87

Note: * denotes significant differences, p1: p value on comparing before music versus during music; p2: p value on comparing during music versus after music; p3: p value on comparing before music versus after music.

Discussion

Music was considered a very important factor for sedation, and blood-pressure reduction. Music therapy, a cost effective treatment was found to reduce anxiety even in patients with myocardial infarction [11]. Its therapy have enhanced parasympathetic activity and reduced sympathetic activity in elderly patients with cerebral vascular disease and dementia [12]. However, there are contradictory findings regarding the effect of music on heart rate variability. Some reports claim that music listening enhances parasympathetic activity which was more pronounced in females [13]. Other authors report that there is no change in HRV, while listening to relaxant classical music [7]. In addition, a few mention that the relaxing music can increase the parasympathetic

activity of the nervous system [9]. Therefore, we compared HRV in male medical students at three time points: before listening to music, during listening it and after hearing it.

In our results, except for the mean RR (a marker of parasympathetic activity) which was increased during music as compared to before music session, there were no significant differences in other time domain measures in all the sessions. This shows that the parasympathetic activity was increased during listening to music. In addition, there was a significantly higher HF power after listening to music as compared to during listening to music. This further shows that the music had modulated the autonomic nervous system and its effect was remained even after over of it. That lead to a more relaxed state of heart as parasympathetic activity was increased even after the music session. As well as, the total power was significantly higher after listening to music as compared to before listening it. Hence, this showed that the parasympathetic activity was increased during music listening and its effect remained in body even after the music was over. Hence, our results support that the music (soft instrumental) enhances the relaxation of the heart and increases the parasympathetic activity of the heart, as reported earlier by Zhou et al, 2010 [9].

A report also mentions that the classical music has a beneficial effect on HRV and reduces the stress level in medical students, as the autonomic balance shifted towards the improvement of the parasympathetic tone [14]. They reported that the music group had a significant increase in the total power and high frequency normalized unit as compared to the non-music group, supporting our result. However, it has been reported that the excitatory heavy metal music acutely decreases global HRV in males [7], which contradicts our result. The contradiction might be due to the selection of different type of music in their study i.e. heavy metal music. In addition to this, in women it has been found that the relaxant baroque and excitatory heavy metal music slightly decreases global heart rate variability [6], which also contradicts our findings obtained from the male population. However, a report has shown that the music listening enhances parasympathetic activity more in the females as compared to the males [13]. The variability in gender may be due to the hormonal factors. Menstrual cycle phases may influence the HRV [15] and brain activity in women. Further study is required to evaluate the acute effect of listening instrumental-soft soothing music in women at different phases of the menstrual cycle. Thus, our result indicates that the instrumental-soft soothing music (instrumental) listening for short duration (five minutes) increases the parasympathetic activity of the heart in adult males.

The possible mechanism for change in the autonomic control while listening to music has been proposed by many researchers. Some have proposed that hearing nerves pass music signal to the nerve center, then affect the cerebral cortex and hypothalamus, causing autonomic nervous system's responses, which in turn affects the automaticity of sinus and the rhythm of the heart rate [9]. Others have suggested that music leads to increased calcium/calmodulin-dependent dopamine synthesis in the brain, thus reduces the blood pressure. This inference has been drawn from the study done in the spontaneously hypertensive rats exposed to music. Finally, they proposed that activation of D2 receptor regulates the vasomotor center, which will suppress the peripheral sympathetic nerves firing and ultimately decreasing the blood pressure [16]. As dopamine is regulating the vasomotor center, it might increase the parasympathetic and decrease the sympathetic activity to the heart, which ultimately increases the HRV while listening to the music. This mechanism might be playing role to increase the parasympathetic activity of the heart in human beings.

In our result, students reported that the five minutes of music listening, made them feel relaxed and relieved their stress too. They reported that their brains were relaxed during and after the music session. Our study group was medical students who were under the medical education stress, so they were considered to be one of the models for the neuropsychological study. Hence, the cardiovascular recovery will be better by music in students who were under emotional stress or anxiety and facing the challenges of medical education stress. Our day to day lives includes high work load and competition in

the work place. Therefore, one can use music for a short period to relieve their stress at their work place. It has been reported that four weeks of music therapy to male elite shooters had decreased salivary cortisol level indicating a decrease in pre-competition stress [17]; ultimately they performed well in the sports competition. Additionally, the cortisol has permissive action to epinephrine to increase the blood pressure and the heart rate. Therefore, reduction of cortisol levels by music therapy may help to decrease the blood pressure and increase the HRV in persons who handles stressful job. A study has also shown that the music therapy was effective to reduce behavioral and psychological symptoms in dementia patients too [18].

Music listening during the early post-stroke stage has enhanced cognitive recovery and prevented negative mood [19]. Therefore, music can be one of the cost effective treatments to relieve the mental stress and improve the person's performance in the work place. However, some findings do not fully support the notion of using music listening as a successful stress management tool, at least not in the context of anticipating an upcoming stressor [20]. Because listening to relaxing music prior to a stressor did not decreased the endocrine stress response, but tended to increase it. Instead, there was an advantage that music listening group prior to stress showed a faster autonomic recovery after stress compared to the control groups (no music group).

This shows that the music has a role to modify autonomic control of the heart. It helps persons somehow by minimizing their stress level and fastens the autonomic recovery after encountering the stress. As well as, a report showed that the Hanuman Chalisa music reduced blood pressure in MBBS subjects, of aged 18 to 22 years [21]. In addition to this, listening to Gayatri mantra had decreased reaction time and reduced distractions in their work area. This helped them to increase the concentration along with delays in the fatigue [22]. Hence, it seems that students can use music (short duration) to decrease their education related stress in their workplace whenever they feel stressed and can boost up their mental energy for the study.

Our findings did not show significant differences in comparing blood pressure and heart rate variables between before and after the music sessions. This might be due to the short duration (five minutes) of music listening and small sample size. Thus we need further study to draw a better conclusion on it.

Conclusion

Finally, we conclude that the instrumental-soft relaxing music for short duration (five minutes) can increase the parasympathetic activity of the heart and makes people feel relaxed which helps them in minimizing their stress instantly. Hence, the students hearing music for five minutes help them to decrease their educational stress in their workplace. Since, the parasympathetic activity was increased during listening to music and HF power an indicator of parasympathetic activity was remained in higher state even after over of the music. This shows that the music had modulated the autonomic nervous system and increased the relaxed state of the heart.

The limitations of our study could be minimized if we had estimated cortisol and endorphins levels during all the sessions. It could be better if we had used both men and women with more liberal inclusion criteria (sample size) in order to reach the more general conclusions. However, we were confident that the music stimulus which we have used in our study has stress-attenuating capacity. This was confirmed by the result obtained from the subjective feeling of all (15/15) the participants.

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